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3.	Full name, address and postcode of the or of each applicant *(underline all surnames)*	Downhole Products plc Badentoy Road Badentoy Park Portlethen Aberdeen AB12 4YA
	Patents ADP number *(if you know it)*	7159171002
	If the applicant is a corporate body, give the country/state of its incorporation	United Kingdom
4.	Title of the invention	"Apparatus"
5.	Name of your agent *(if you have one)*	Murgitroyd & Company
	"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*	165-169 Scotland Street Glasgow G5 8PL
	Patents ADP number *(if you know it)*	1198015
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Signature

MURGITROYD & COMPANY

Date 25/03/2004

12. Name and daytime telephone number of person to contact in the United Kingdom

Jamie Allan 01224 706616

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"Apparatus"

The present invention relates to apparatus for mobilising drill cuttings in an oil or gas well.

The art of drilling wellbores for recovery of oil and gas is well known. One particular problem faced by this art is the removal of cuttings from the well as they are generated by the action of the drill bit cutting into the formation. The cuttings need to be removed from the bit and conveyed back to surface as efficiently as possible, as their persistence in the wellbore hampers drilling activity, and tends to reduce the productivity of the well.

Cuttings are washed back to surface by drilling mud or fluid pumped down the string, out through the bit, and back up the annulus surrounding the string. This solution is generally satisfactory, but in long and deviated wells we have found that cuttings still tend to clump and impede the drilling activity, or the production of the well.

According to the present invention there is provided apparatus for mobilising drill cuttings in a well, the apparatus comprising at least one vane, and two or more blades defining at least one fluid conduit between adjacent blades, the blades being configured to create a pressure difference in fluid flowing through the conduit, and the blades and vane being rotatable relative to one another.

The apparatus typically comprises a sleeve or collar, which is typically tubular and is adapted to fit over a string in the well. The string can be a tubing string, drill string, or casing string etc. Typically the vanes are provided on the sleeve.

Typically the blades are mounted on a bushing that is rotatably mounted on the sleeve.

However, in certain simple embodiments, it is sufficient to provide the vanes direct on the tubing string (or on a sleeve attached to the string) and to provide the blades on an adjacent part of the string, or on a separate sleeve attached thereto, so that the blade-bearing bushing is not directly attached to the vanes-bearing sleeve.

Typically the sleeve is adapted for attachment to a drill string, and the fixing means typically comprises a clamp means such as an annular clamp to fix the sleeve over the outer surface of the drill pipe. However, the sleeve may equally attach to casing or any other oilfield tubular goods.

The vanes can be carried direct on the sleeve, or in some embodiments can be provided on a separate bushing rotationally (or otherwise) affixed to the sleeve. The vanes typically rotate with the drill string in normal rotary drilling operations as they are typically rotationally fixed to the drill string. The rotation of the vanes agitates the fluid surrounding the apparatus, and creates thrust tending to drive the fluid past the sleeve.
The blades of the bushing typically create a pressure drop in the fluid as it flows past the apparatus, driven by the rotation of the vane(s).

Typically the bushing is free to rotate relative to the sleeve, which is affixed to the drill string. Thus, upon rotation of the drill string (or casing) during normal rotary drilling, the bushing typically remains stationary relative to the wellbore, while the drill string rotates.

Typically the blades on the bushing project radially outward to a greater extent than the vanes of the sleeve, so that the radially outermost surface of the blades contacts the inner surface of the bore within which the string is located, and this centralises the sleeve within the bore. In preferred embodiments, the vanes are radially lower than the blades, and can freely rotate within the bore, as the higher blades provide a stand off against the inner surface of the bore. The bore can be the unlined wellbore, or can be the bore of

casing, liner or other tubing in which the apparatus is located.

The blades typically have an asymmetric profile, and in preferred embodiments the blades are shaped in the form of foils, so that the fluid conduits defined between adjacent blades on the bushing change in profile. Typically the fluid conduits are relatively narrow at a lower end (nearest the drill bit) and grow relatively wider toward the upper end (furthest away from the bit). The increase in dimension from the bottom of the channel to the top causes a pressure drop in the fluid flowing through the channel.

Typically the bushing can be formed from a rigid material, such as hard rubber or metal. The sleeve is typically formed from metal such as steel, alloy, aluminium, etc.

The sleeve can have an annular body to fit around a tubular or string of tubulars. The annular body can have the vanes integrally formed with it, for example by moulding the sleeve and vanes as a single piece. In alternative (and preferred) embodiments, the sleeve can have vane-receiving recesses therein to receive and retain modular vanes, which can be slotted in the recesses, and retained therein. This has the advantage that several different sizes of vanes can be used with a single sleeve.

Likewise, the blades on the bushing can be modular and can be received within blade recesses in the same manner.

The vanes are typically curved, and in preferred embodiments they cross the axis of the sleeve. In especially preferred embodiments they are configured in a sinusoidal "lazy-s" shape and this helps to agitate the fluid surrounding the apparatus during rotation.

The invention also provides a drill cuttings agitation assembly, comprising a tubular, a vane, and at least two blades defining at least one fluid conduit between adjacent blades, the blades being configured to create a pressure difference in fluid flowing through the conduit, and wherein the vane and the blades are rotatable relative to one another.

The invention also provides a method of agitating drill fluid in an oil or gas well, the method comprising passing the drill fluid past a vane rotatable relative to at least two blades, which are configured to create a pressure difference in the fluid passing them, whereby a pressure difference is created in the fluid as it passes the blades.

An embodiment of the invention will now be described by way of example and with reference to the accompanying drawings, in which:

Fig. 1 is a side view of apparatus according to the present invention, mounted on a tubular;

Fig. 2 is a close up side view of the Fig 1 apparatus;

Fig. 3 is a side view of a sleeve of the Fig 1 apparatus;

Fig. 4 is a side view of a bushing of a bushing of the Fig 1 apparatus;

Fig. 5 is a side view of a clamp of the Fig 1 apparatus;

Figs. 6 and 7 (respectively) plan and underside views of the Fig 4 bushing;

Fig. 8 is a flat view of a bushing half shell;

Fig. 9 is a side view of a bushing blade;

Fig. 10 is a plan view of a sleeve;

Fig. 11 is a sectional view through a clamp;

Fig. 12 is an outer side view of a second sleeve;

Fig. 13 is an inner side view of the second sleeve;

Fig. 14 is a sectional view through the second sleeve;

Fig. 15 is a perspective view of a modular vane for the second sleeve;

Fig. 16 is an underneath view of the Fig 15 vane;

Fig. 17 is a plan view of the Fig 15 vane; and

Fig. 18 is a side view of the same vane.

Referring now to the drawings, apparatus for mobilising drill cuttings in a well comprises a sleeve 5, a bushing 7 and a clamp 9. All of these components are generally tubular, but are axially

divided into two separate leaves that are hinged together. The leaves of the sleeve 5 are hinged at three locations 5h, and its two leaves pivot around those hinges to enable the sleeve 5 to be opened and closed around a tubular T such as drill pipe or casing. The two halves of the sleeve are locked together by one or more bolts 5b at a position diametrically opposite to the hinge 5h, so that the sleeve 5 can be tightly fastened to the tubular T by means of the bolts.

The hinges 5h are located on an upper part of the sleeve 5, beneath which is a bearing region 6 having a reduced outer diameter as compared with the nominal diameter of the upper region. An annular groove 6g is formed on the lower end of the bearing region 6, and a shoulder 6s divides the upper and bearing regions of the sleeve.

The bushing 7 is also formed as two separate leaves that are connected together at diametrically opposed positions by interlocking castellations and connecting pins 7p, about which the two leaves can pivot. The two leaves of the bushing 7 are typically closed around the bearing region 6 of the sleeve, at which point the leaves are connected together by inserting the pins 7p into axially aligned bores on the interlocking castellations to close and lock the bushing 7, so that the bushing 7 is connected to the sleeve 5.

After the bushing 7 has been locked in place around the bearing region 6 of the sleeve 5, the clamp 9 is then placed around the lower end of the bearing region 6, so that an annular lip on the internal surface of the clamp 9 engages in the external annular groove 6g on the lower part of the bearing region 6. The clamp 9 is then closed and fastened by means of bolts (not shown) in the same manner as the bolts 5b that lock the sleeve closed around the tubular T.

When thus assembled, the tightening of the bolts in the sleeve 5 and the clamp 9 securely connects the sleeve to the tubular, so that the two are rotationally connected, and thus the sleeve rotates with the tubular.

The bushing 7 is fixed to the bearing area 6 of the sleeve, and is prevented from axial movement by the shoulder 6s above it, and the clamp 9 below it; however, the bushing 7 is free to rotate around its axis relative to the sleeve and the clamp, and the tolerance of the outer diameter of the bearing region 6 and the inner diameter of the bushing 7 are chosen to permit a degree of play between the two, and allow rotation of the bushing 7 around the axis of the sleeve 5.

The sleeve 5 has vanes 12 mounted on the upper large diameter section. As best shown in Fig. 10, two vanes 12 are mounted on each leaf of the sleeve, and the vanes are spaced apart on the circumference of

the assembled sleeve 5 at equal distances, so that the vanes 12 are arranged in diametrically opposed pairs.

The vanes 12 have a generally sinusoidal shape with a lower scoop 12s, a generally axial mid-region 12m, and an upper deflector portion 12d.

In side profile, the vanes 12 are generally arcuate in the scoop and deflector regions, rising from the plane of the sleeve 5 in a regular arc until a plateau is reached at the mid-section 12m. Fig. 18 shows the side profile of a typical vane 12. The vanes 12 project radially from the outer surface of the sleeve 5, so as to create between adjacent vanes 12 a fluid path that is generally sinusoidal in shape.

The bushing 7 has blades 15. Typically, there are three blades arranged on each leaf of the bushing 7, and typically these are circumferentially spaced at equal distances, so that the blades 15 are arranged in three diametrically opposed pairs, as best shown in Figs. 6 and 7. Each blade 15 is arranged generally parallel to the axis of the assembled bushing 7, and in plan view, each blade 15 is in the general shape of a foil or wing, as best shown in Figs. 2 and 8. In detail, each blade 15 has a lower end 15l that widens from the lowermost tip of the blade to an apex 15a, from where it tapers through a mid-section 15m, to an upper end 15u, and finally to a slim point at the upper end. Shaping adjacent

blades like foils in this manner creates a flow path between adjacent blades that rapidly narrows to a throat at the level of the apex 15a of the blades, and then gradually widens as the passage passes the upper ends 15u of the blades.

As best shown in Fig. 9, the side profile of each blade 15 rises from the plain of the bushing 7 at the tips and is arcuate in the upper 15u and lower 15l ends, and forms a plateau in the mid-section 15m.

The nominal external diameter of the bushing 7 is generally very close to the nominal external diameter of the upper part of the sleeve 5, and also matches that of the clamp 9, so that apart from the vanes 12 and the blades 15, there are no upsets on the outer surface of the apparatus.

The radial extent of the blades 15 typically exceeds the radial extent of the vanes 12, so that the mid-section 15m of the blades contacts the inner surface of the bore in which the apparatus is deployed, thereby spacing the vanes 12 from the inner surface of the bore.

In preferred embodiments, the blades 15 are integrally formed with the leaves of the bushing 7, and in typical embodiments, the two leaves can be cast or moulded each in a single piece with their respective blades. Alternatively, the blades can be

formed separately and attached to the body of the bushing 7 as required.

The vanes 12 can also be cast or moulded integrally with the separate leaves of the sleeve, but in preferred embodiments, the vanes 12 (and optionally the blades 15) can be separately cast or otherwise formed from the same or a different material, and can be assembled with the sleeve prior to use in a modular fashion.

One such arrangement is shown in Figs. 12 to 18.

In this embodiment, the sleeve 5 has a vane-receiving portion 20, which comprises a region with an increased inner diameter. Each vane 12 has a base plate 12b attached to its radially innermost face as shown in Fig. 15. The base plate 12b is curved, with an outer diameter that matches the inner diameter of a vane-receiving portion 20 of the sleeve.

When the sleeve 5 is to be assembled with the modular vanes 12, the radially outermost mid-portion 12m of each vane is offered to a vane-shaped slot 18 in the vane receiving portion 12, so that the mid-portion 12m passes from the inner surface of the sleeve 5 through the vane receiving slot 18, and extends radially outward from the outer surface of the sleeve 5. The curved radially outer face of the base plate 12b of each vane 12 matches the inner diameter of the vane receiving portion 20, and the

depth of each base plate 12b is chosen to match the step between the nominal inner diameter of the sleeve 5 and the nominal inner diameter of the vane receiving portion 20, so that when the modular vanes are assembled with the sleeve 5, the base plates 12b are accommodated within the vane-receiving portion 20, and the inner diameter of the sleeve and base place are contiguous. The assembled sleeve with modular vanes 12 can then be clamped onto the tubular T as previously described.

Modular vanes 12 give the advantage that worn vanes can be replaced easily, and different sizes or profiles of vanes 12 can be used with the same sleeve body. Also, vanes of different materials or properties can be provided on a generic sleeve 5, and if desired, modular vanes 12 having different characteristics can even be provided on the same sleeve 5.

It will be appreciated that modular blades 15 can be provided for the bushing 7 in the same way.

Typically the bushing 7 and blades 15 are formed from a hard material such as a hard rubber or plastic. Metals are also useful for the formation of the bushing 7, and aluminium, zinc alloy, or austemperised ductile iron can be used for this purpose.

The sleeve 5 and vanes 12 need not be formed from the same material as the bushing 7 and blades 15,

and in preferred embodiments, metals or plastics can be used for the vanes 12 and/or the sleeve 5.

In use, when the apparatus is clamped to a tubular T such as a drill string that is being used to drill a well, the device is typically deployed at regular intervals along the bore, and can be used from a position relatively close to the drill bit right up to the top of the bore. The weight of the string T typically forces the mid-portion 15m of the blades 15 against the inner surface of the wellbore, so that the string is spaced away from the inner surface of the wellbore by the radial extent of the blades 15. Since the sleeve 5 is securely rotationally fastened to the drill string T, the sleeve 5 and hence the vanes 12 rotate in the direction of arrow A in Fig. 1, ie clockwise when viewed from the top of the string. However, since the weight of the string is pressing the blades 15 against the inner surface of the wellbore, and since the bushing 7 is rotatable on the bearing area 6, the bushing 7 remains stationary relative to the wellbore, and the sleeve and vanes 12 rotate relative to the bushing 7 along with the string.

The radial dimensions of the blades 15 exceed those of the vanes 12, and thus the vanes 12 are spaced from the inner surface of the bore, and are not impeded from rotating by contact with the inner surface of the wellbore. The rotation of the vanes 12 and the speed of the string (typically 120-180 rpm with normal rotary drilling, but sometimes as

slow as 20 rpm with casing drilling) generates turbulence in the drill fluid in the annulus between the string and the wellbore. The sinusoidal arrangement of the vanes 12 generates thrust in the drill fluid in the region of the apparatus, and in particular, the scoops 12s drive the drill fluid up through the fluid passageways between adjacent vanes, and the deflectors 12d accelerate it out of the top of the fluid passage. In addition to creating thrust in the fluid and pumping the fluid from the lower end of the apparatus to the upper end, this also creates turbulence in the fluid, tending to break up clumps of drill cuttings, to keep the fluid in a liquid phase.

The rapid rotation of the vanes 12 in the drill fluid creates a pressure drop in the area between the vanes 12 and the blades 15, which draws more fluid up through the channels between adjacent blades 15. As the fluid passes the apex 15a in the channels between adjacent blades 15 on the stationary bushing 7, it experiences a further pressure drop created by the expansion in volume of the fluid passageway as each blade narrows towards its upper end. The pressure changes occurring as a result of this speeds up fluid flow from the bit to the surface, and also suspends cuttings in the liquid phase, which makes it easier to return them to surface.

An additional advantage of the non-rotating bushing 7 is that it reduces torque for rotation of the

string T within the hole, and the bearing surface between the sleeve 5 and the bushing 7 is typically lubricated by the drill fluid passing the apparatus. In addition to this advantage, the smooth outer surface of the blades 15, and particular the rounded profile of the ends of the blades 15u and 15l, can reduce drag while running in the hole, thereby also reducing casing wear, and enhancing the penetration of the drill bit. If the bushing 12 is manufactured from materials having a low co-efficient of friction then additional advantages in running in the hole are also achieved. Notably, plastics, rubber and zinc alloys give useful secondary advantages in this respect.

The provision of the non-rotating bushing also reduces drill string harmonics, and can help to prevent differential sticking of the string.

Modifications and improvements can be incorporated without departing from the scope of the invention.

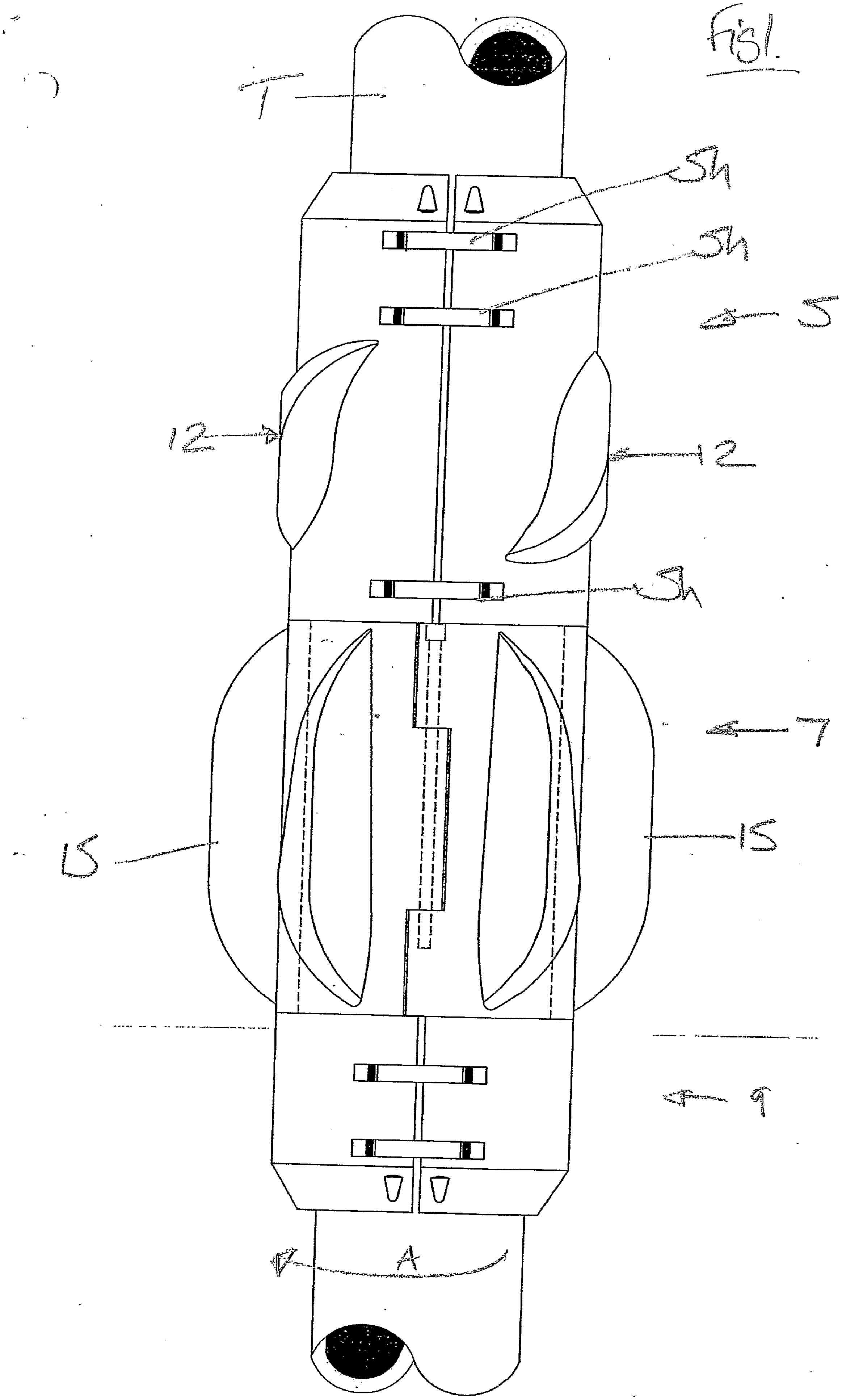
Fig1.
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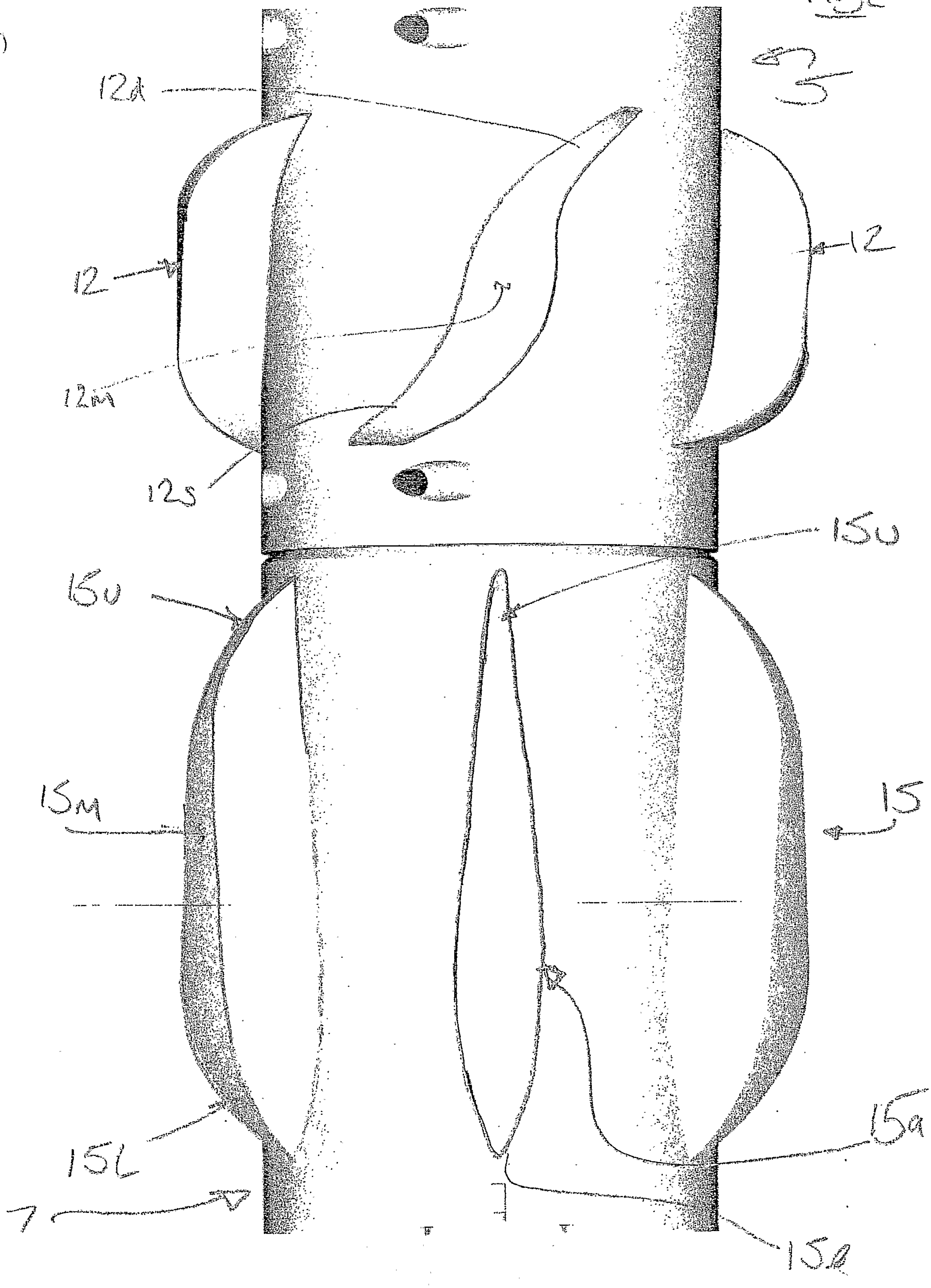
Fig 2



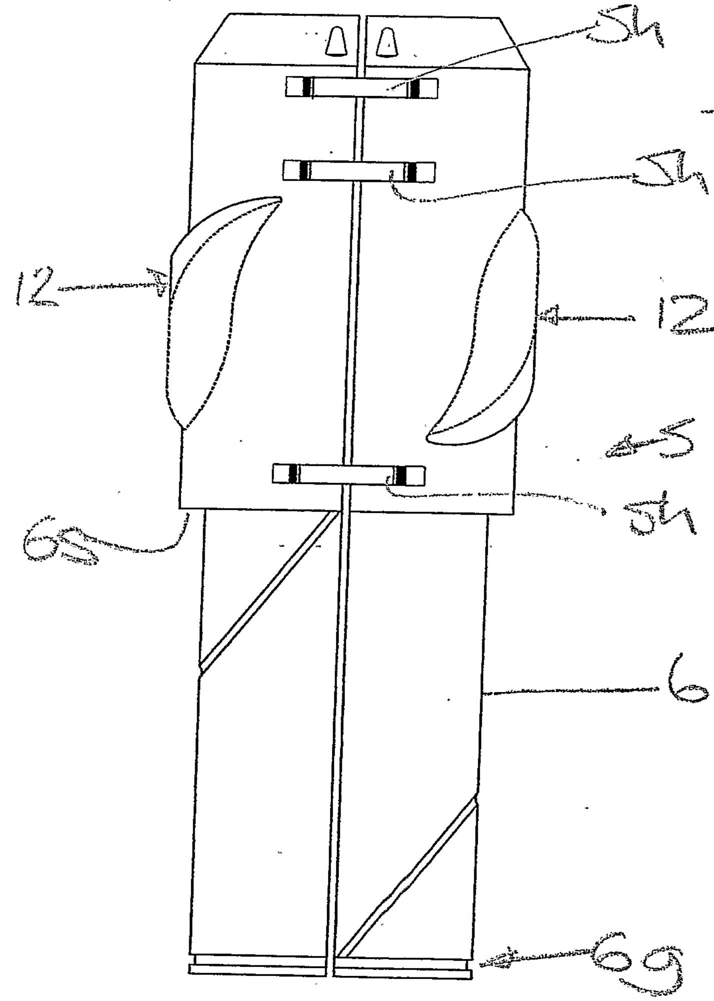
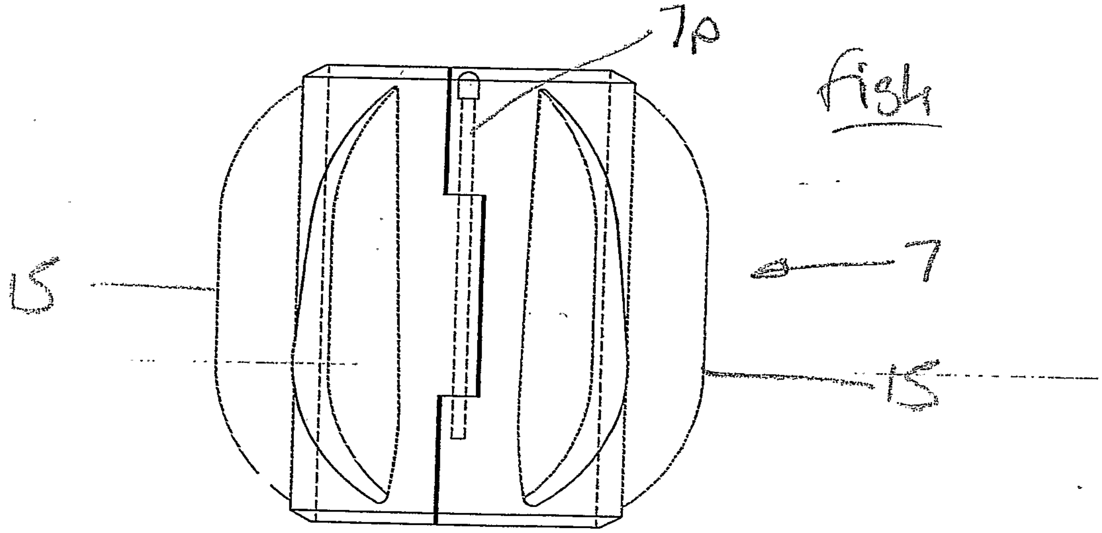


fig3



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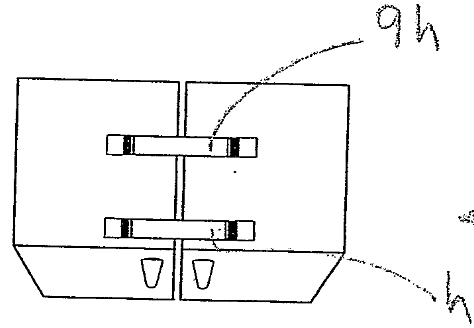

fig5

fig6

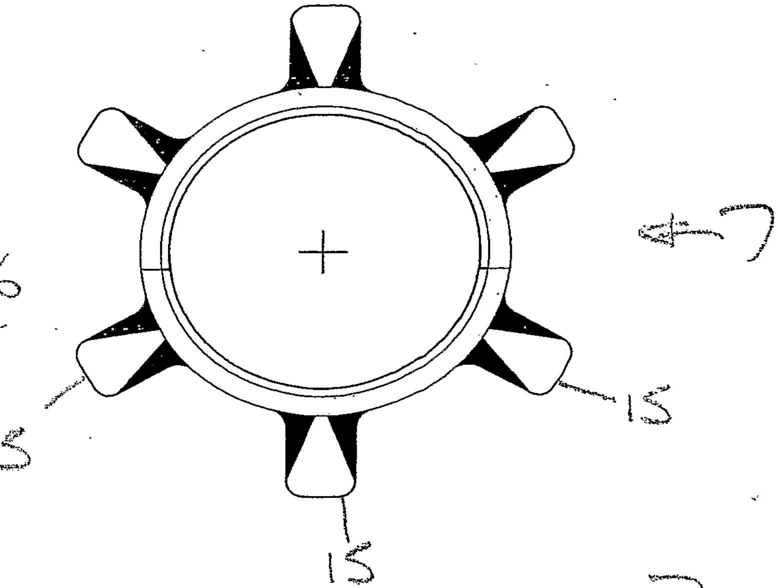

fig8

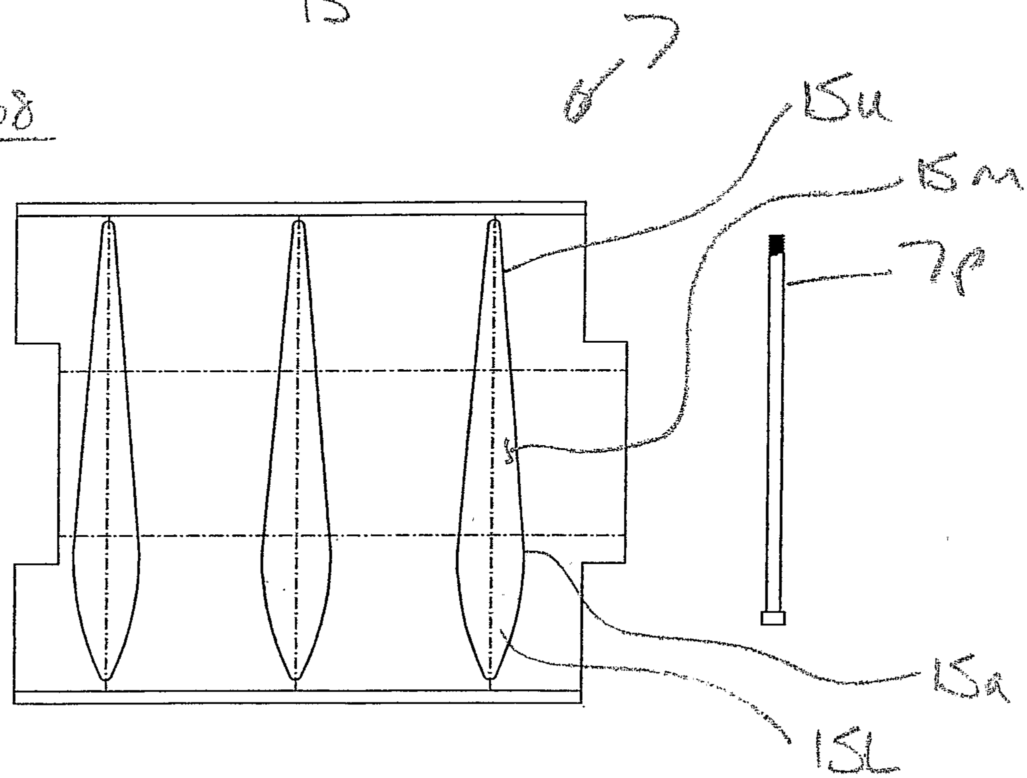

fig9

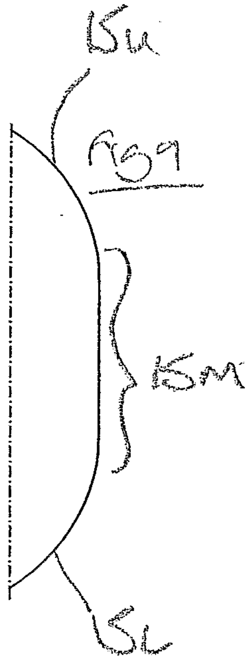

fig7

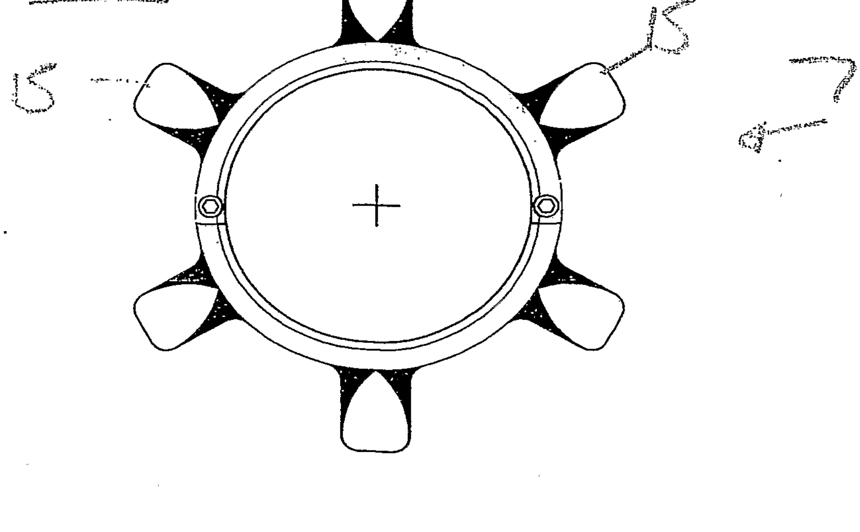

Fig 10

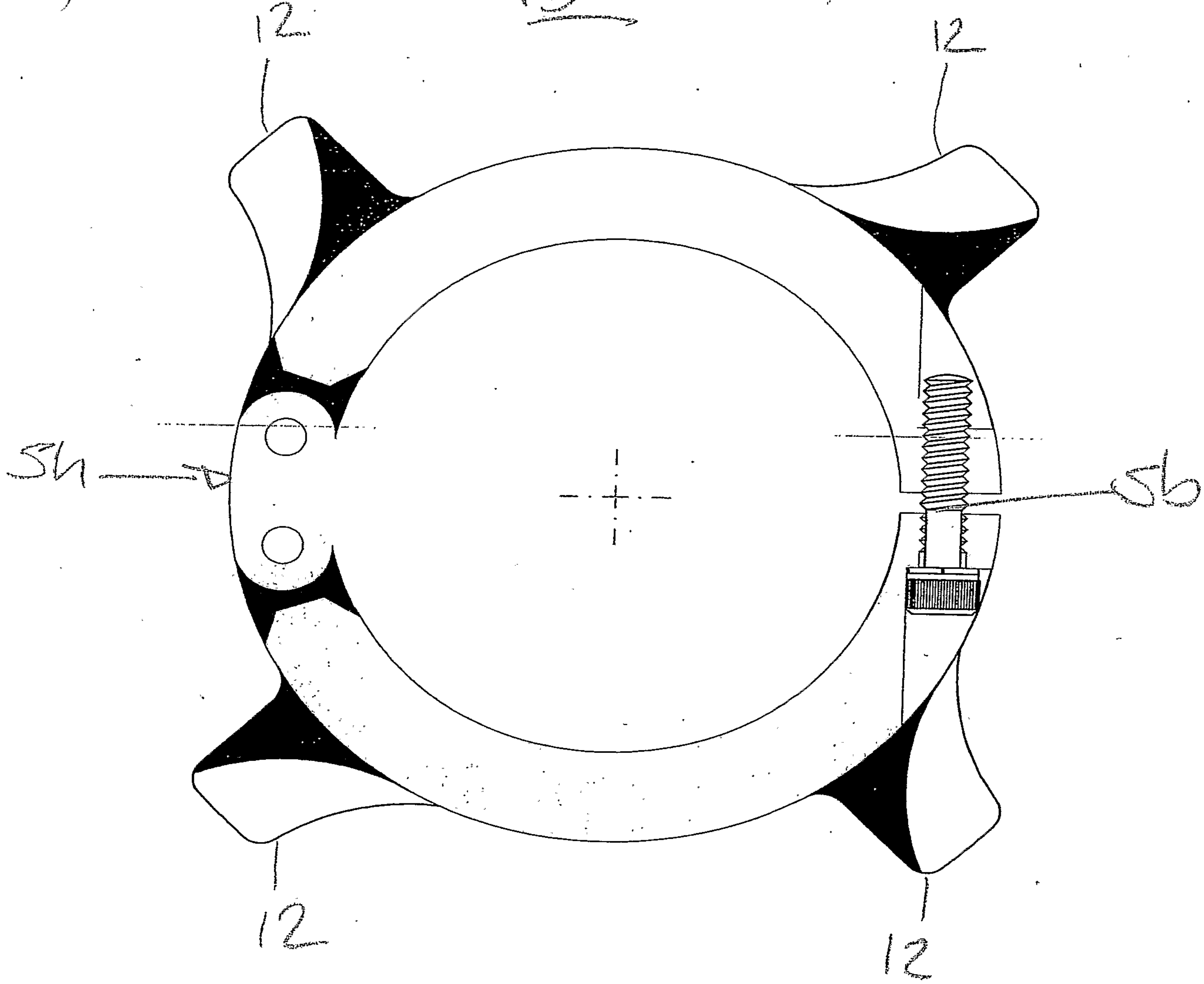

Fig 11

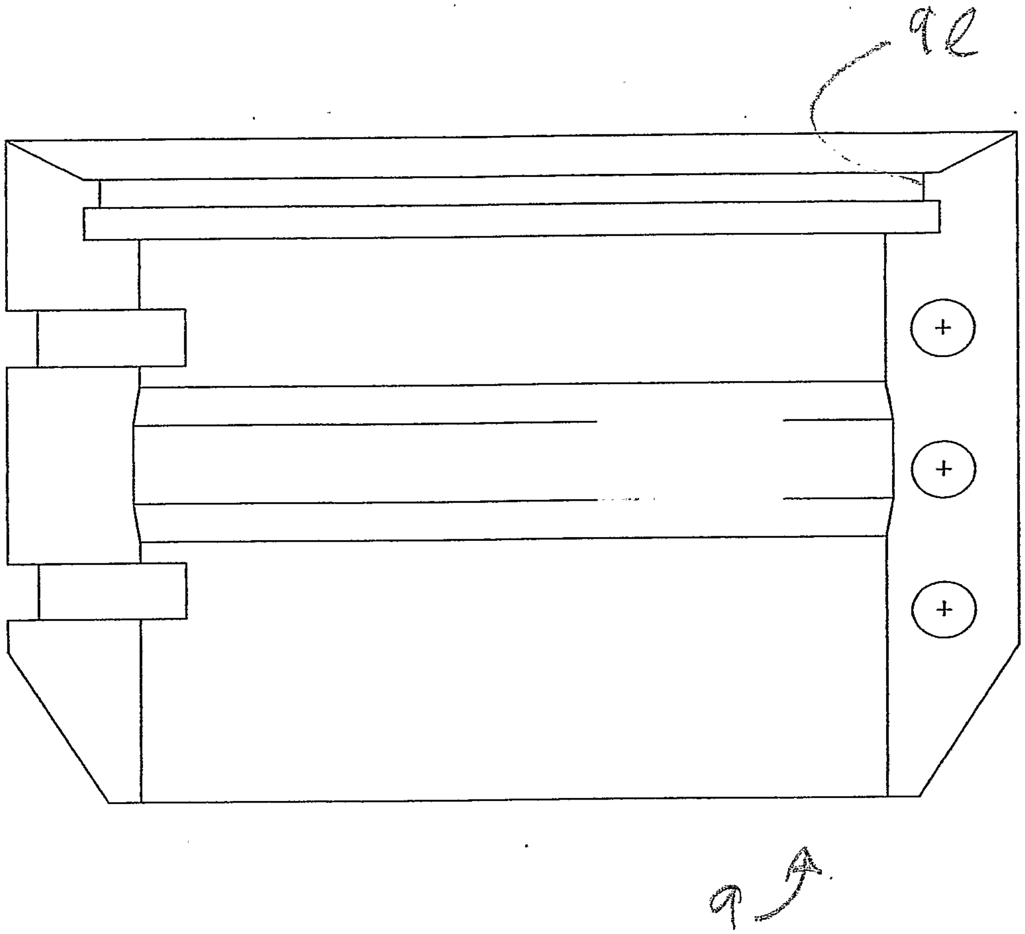

Fig 13

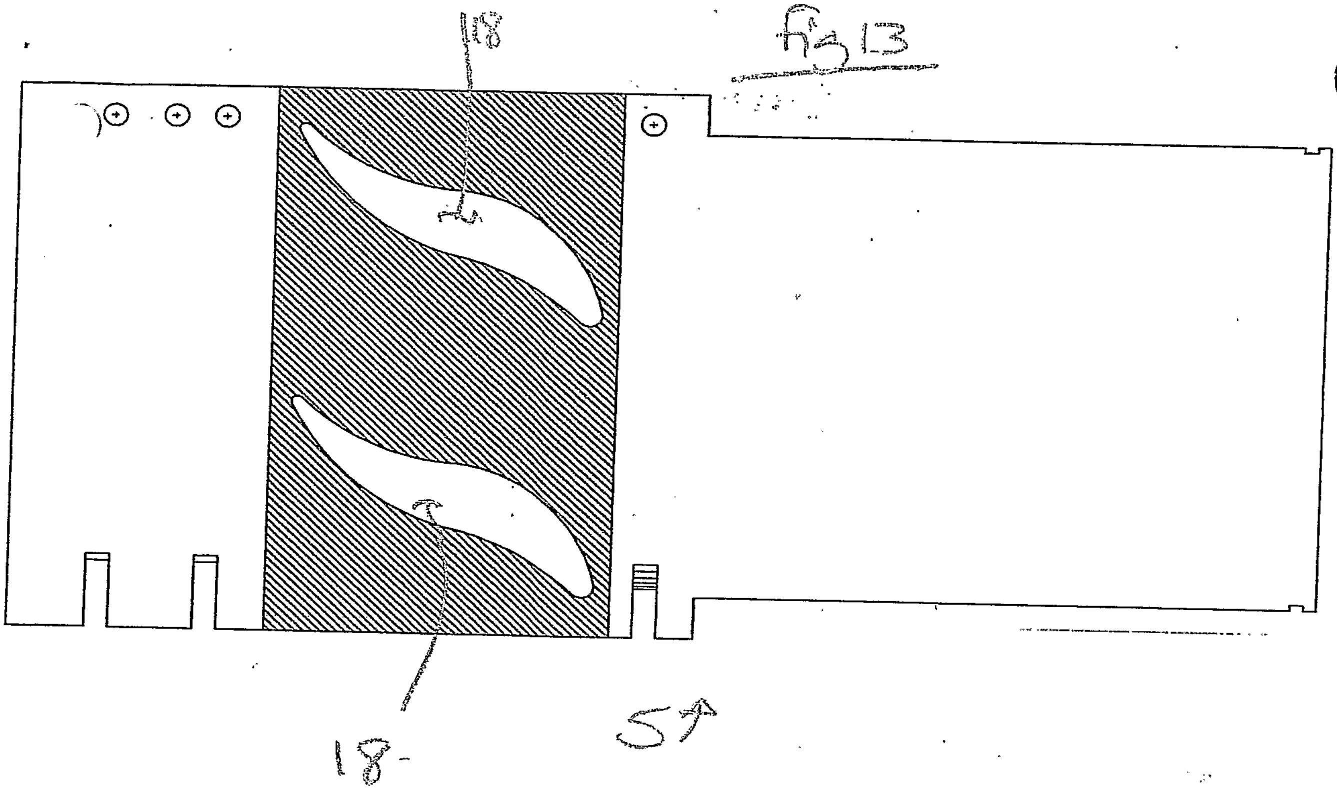

Fig 12

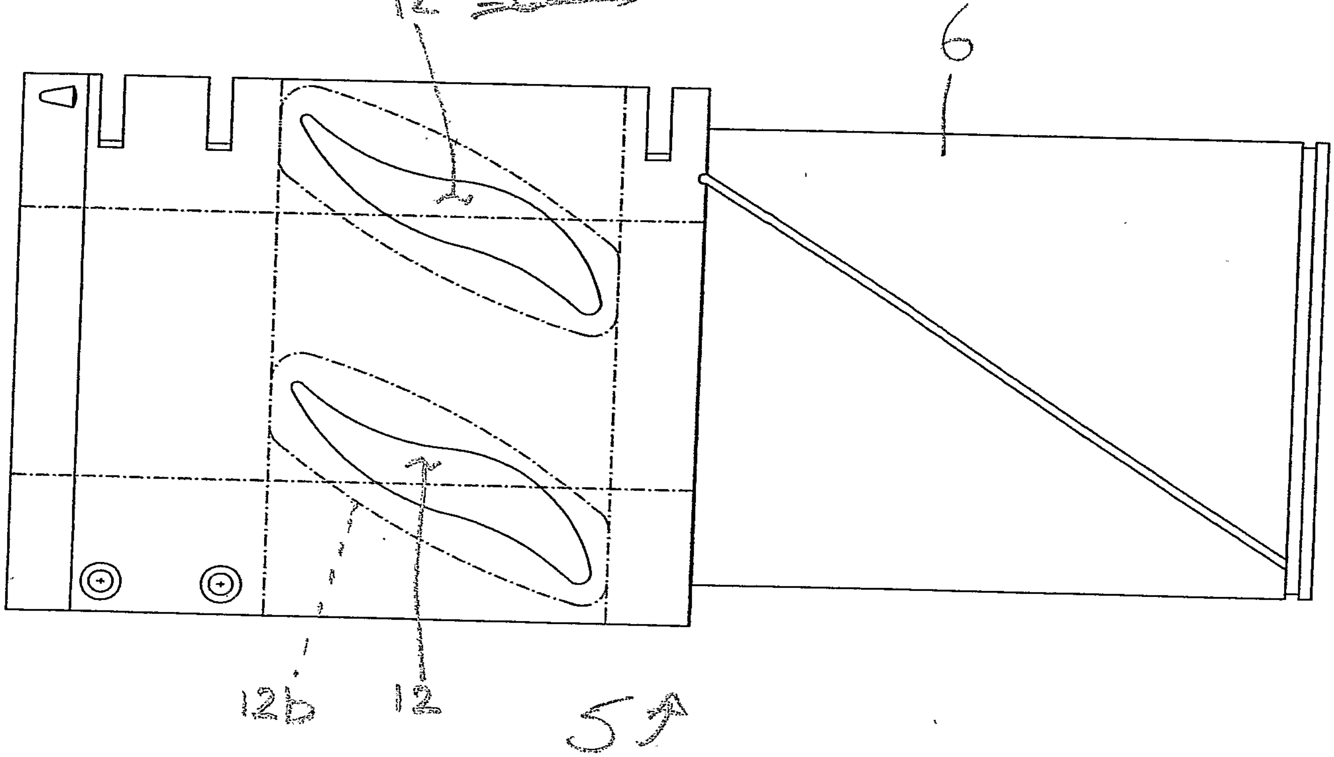

Fig 14

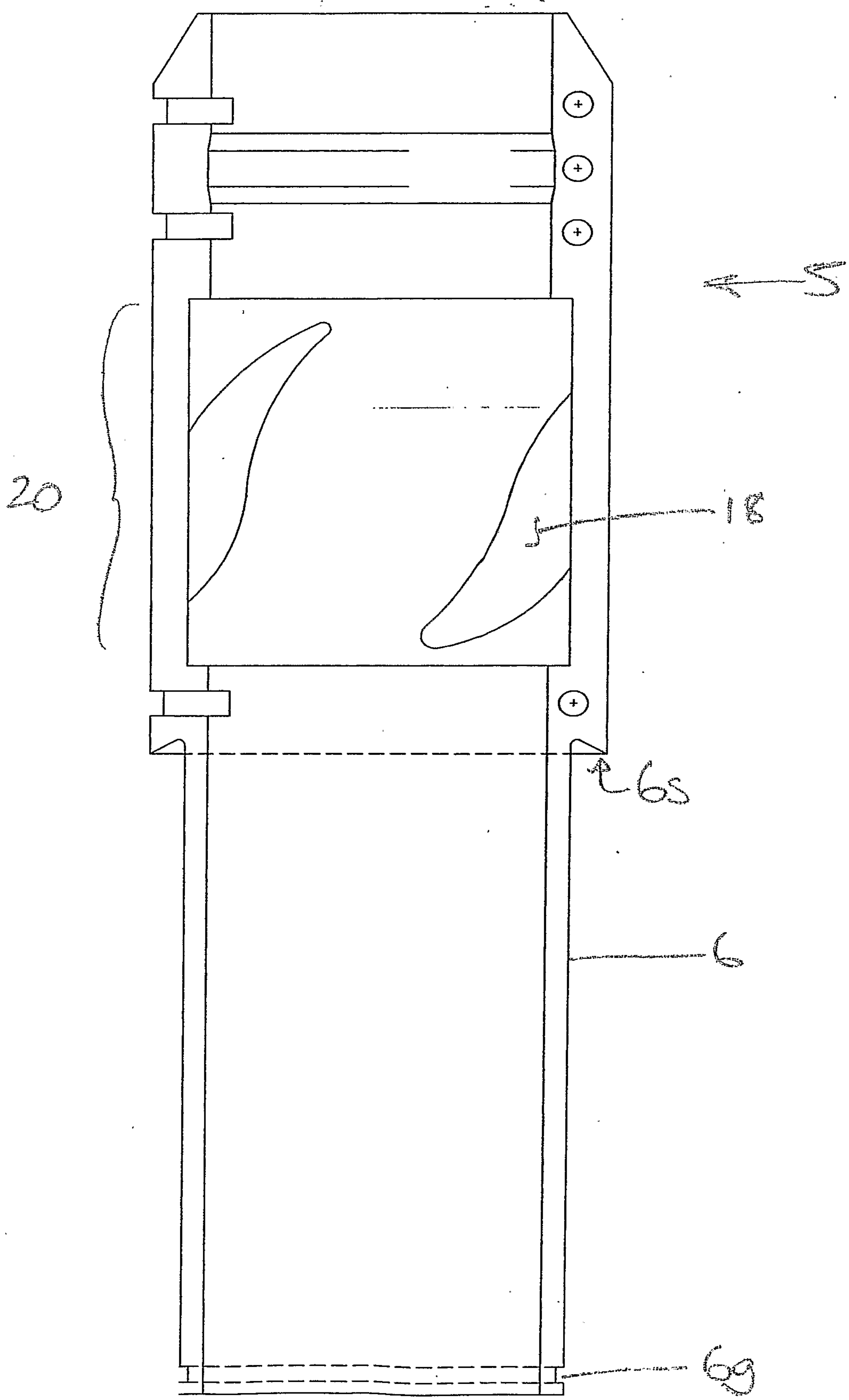

Fig 15

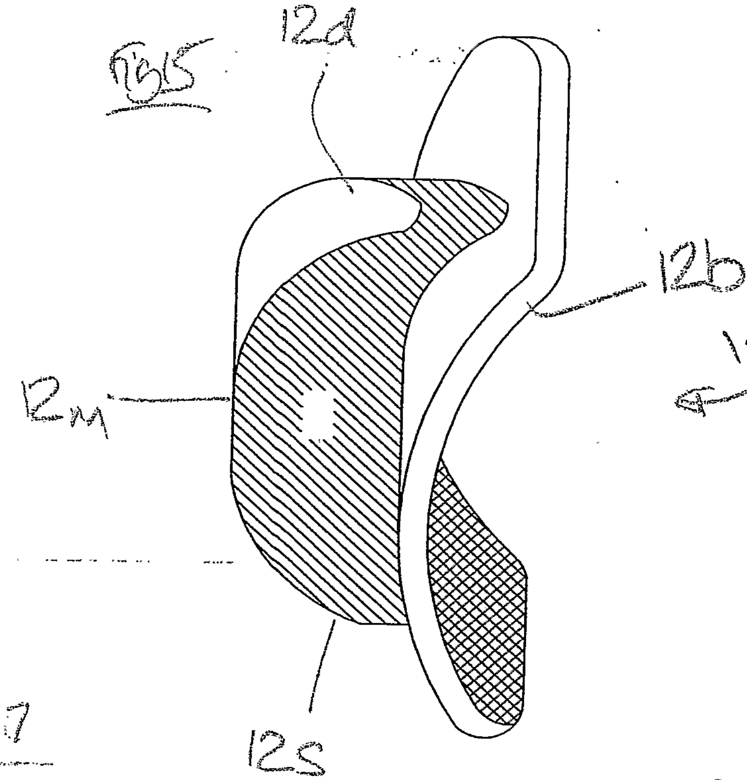

Fig 17

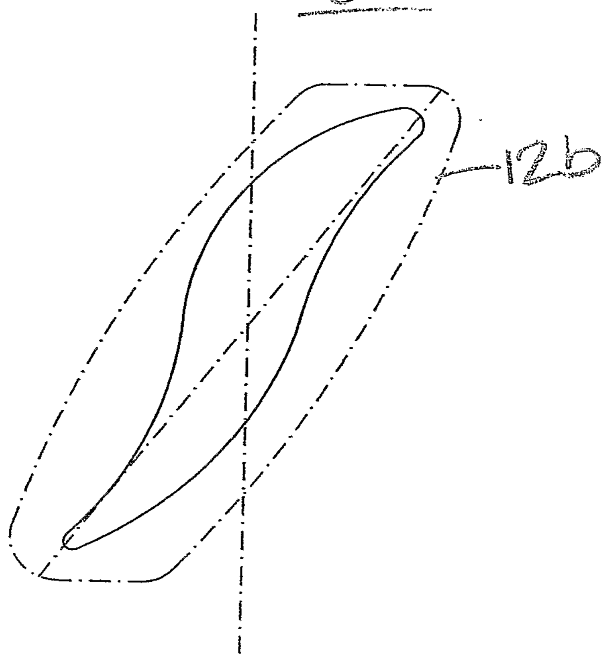

Fig 16

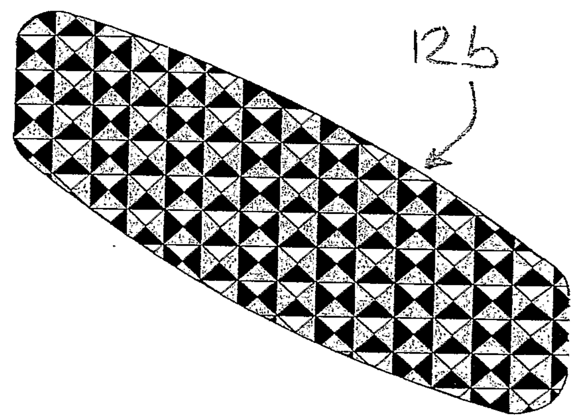

Fig 18